Synopsis

REVEGETATION ENHANCED SLOPE STABILISATION OF OVERBURDEN DUMPS FOR IMPROVED SAFETY

Department of Botany

Binod Bihari Mahato Koyalanchal University,Dhanbad

Guide:

Dr. J. N. Singh

Associate Professor, Botany Department,

R.S.P College, Jharia

BBMKU, Dhanbad

Co-Guide:- 1

Dr. Sanjay Kumar Roy

Sr. Principal Scientist

Slope Stabilisation and Landslide Management

CSIR- CIMFR, Dhanbad.

Candidate's Signature

(Rakesh Kumar Singh)

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Ph.D SYNOPSIS

1	Name of the Ph.D student(Block letter)	RAKESH KUMAR SINGH
2	Faculty	Science
3	Name of Department (Wherever applicable)	Botany Department
4	Subject/Specialization	Environmental Science
5	Topic (Block letter)	REVEGETATION ENHANCED SLOPE STABILISATION OF OVERBURDEN DUMPS FOR IMPROVED SAFETY
6	Year of Registration	2020
7	Contact details 1. Residential Address 2. Email 3. Mobile No.	 : CSIR-CIMFR,Colony,Dhanbd : rkscmri@gmail.com : 9431725736,7004225605
8	Details of Ph.D. Guide Designation Department Institute	: Dr. J.N.Singh : Associate Professor : Botany Department : R.S.P College, Jharia,Binod Bihari Mahto Koyalanchal University, Dhanbad
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	Details of Ph. D. Co – Guide -2 Designation Department Institute	: Dr. Sanjay Kumar Roy : Sr. Principal Scientist : Slope Stabilisation and Landslide Management : CSIR-Central Institute of Mining and Fuel Research, Dhanbad.

1. Introduction:

Revegetation is supposed to be the best tool for reclamation of mine spoils [1, 2]. Soil bioengineering techniques that use vegetation as a structural element gained popularity in the field of natural and man - made slopes[3-5].The use of vegetation for slope stabilization started in ancient times. In more recent times, the roles of vegetation in some specific geotechnical processes have been recognised; Vegetation may affect slope stability in many ways. Comprehensive reviews were found in many literatures[6-7].

In open cast mines, the soil management is crucial to the mine's successful operation and environmental clearance. Soil acts as source of dump fertility for the purpose of revegetation. Plant species and soil presence may be used as indicators of mine spoil/overburden chemistry. Trees are being efficient biomass generation, and more organic material (both above-and below-ground) to the soil and associated with a relatively large array of soil organisms, including earthworms[1, 8, 9]. Their deep roots involve a greater depth of raw mine stone in the soil organic system. The anchorage of roots and the improvement of slope stability mainly depend on the properties of root system such as the root distribution and tensile strength [1,10] well as soil conditions.

Revegetation through trees and grasses is one of the widely used techniques for controlling soil erosion and stabilization of dump slope[1,11-12] and consequently maintaining ecological stability of the area [13]. Vegetation growth and succession on dump slope can be described as hydro geological and mechanical actions, [1,14], where the roots play a crucial role in enhancing dump stability by regulating rain water interception and evapo - transpiration and the resulting pore pressure reduction[15], and ultimately regulating hydro geological cycle. Further, plant roots, by mechanical action, reinforce the mine dump material and enhance the shear strength of dump material. This function is closely related to root density, depth and strength [1, 16].

In recent years, there has been increased awareness of the possibility of using vegetation to increase slope stability. Vegetation has been recognized as an effective agent not only for protecting soil from erosion resulting from impacting raindrops and water flow, but also as a factor for significantly increasing the shear resistance of the slope soil[17].

Tree roots can increase soil stability by improving its mechanical and hydrological properties[18].To quantify the contribution of roots to soil stabilization the most commonly considered root traits are root morphology, tensile strength, depth, diameter, biomass and length density. The contributions of roots to erosion control and slope stability depend on root properties [19] and their association with mycorrhiza [20]. Shallow, densely distributed roots

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play a significant role in erosion control by enmeshing soil particles [21] and reducing runoff velocity. Roots also increase soil permeability[22] which means greater water infiltration. Root-derived organic matter binds soil particles and stabilize micro- aggregates[23].

Limit equilibrium analysis considers the slope performance at the equilibrium condition between the resisting and disturbing forces for sliding. To represent the slope performance other than equilibrium condition, it is necessary to have an index and the widely used index to be factor of safety. Factor of safety is calculated as the ratio of shear strength to the available shear stress required for equilibrium, integrated through the whole slide. A factor of safety greater than one is necessary to ensure an acceptably low chance of failure.

The critical approach for evaluating the stability of slopes is to evaluate the factor of safety (FOS)[24]. For the limit equilibrium types of analysis, the FOS is commonly defined as the ratio of the available shear strength along the most critical failure surface, to the shear stress along the surface. Definition of FOS may vary, depending on the analysis method (e.g. ratio of driving force to resisting forces , ratio of overturning moments to restoring moments etc,). However, provided they reflect the fundamental ratio of available shear stress over the whole failure surface, FOS calculated from different methods can be compared.

The study has greater implications for social impact; it will save the infrastructure, land damage, vegetation improvement, and cleaner environment. Which ultimately save human life and wild life population.

2. Statement of the problem:

Opencast mining invariably produces large quantities of waste rocks which is generally piled up into large over burden dumps on the land surface. Overburden (OB) dumps are generally external dumps or can be internal dumps formed by in-pit dumping concurrent to the void or space created by extraction of mineral. Gradual increase in mineral production from opencast mines has resulted in rapid increase in generation of waste rocks which is being accommodated in dumps of greater heights over minimum area giving rise to increasing danger of dump failure. Additional requirement of land for dumping space is forcing many mines to decrease the distance between the toe of dump from crest of pit which may cause pit slope instability. Dump slope failures are matter of serious concern in Indian mining industry, as in recent times several slope failures have taken place causing loss of precious lives and damage to costly machinery. Dash (2019) have listed major accidents due to slope failure during 1901 to 2016 causing 143 fatalities in Indian open cast mines[24]. The most recent accident due to slope failure are Rajmahal coal mine disaster in 2016 and Bharatpur OCP in 2019 causing 23 and 4 fatalities respectively[25]. DGMS (Tech) (S&T) Circular No 02 dated 06.07.2010 have listed a few accidents upto 2010[26].

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The proposed study is aimed at increasing the safety of OB dump by revegetation and thus reducing the risk of failure

3. State of the Art:

The improper management of overburden dumps can cause instability issue which may affect safety and production of the mine. Richards et.al. (1981) conducted an extensive investigation of in-pit spoil pile failure at the Gooyella mine in Queensland, Australia where failure of both in-pit dumps and of the highwall itself significantly impacted mining operation[6]. Failure of an external OB dump servicing a Greek lignite mine resulted in a movement of approximately 40 Mm^3 of material to a distance of 300m and overtopped one earth dam constructed to halt the flow of spoil[27]. In any open cast mine, the management of waste generated during mining is vital,as it contributes greatly to the mine's successful operation. Inappropriate overburden (OB) dump management can result in stability issue which in turn may affect the dump and human safety and the overall production of the mine[28]. Poulsen et.al (2013) studied the failure of 90m high OB dump in SCCL (Singareni colliery) in which displaced spoil travelled approximately 70m from the original location of the dump toe and impacted on neighbouring infrastructure and amenities[28].

Generation of huge quantity of mine spoil dumps causes extensive landscape destruction. The dump materials needs proper place for safe disposal. It is also intricate to get land around the mine due to restriction either by environmental act, forest land or agricultural land. The steeper dump slope is always preferred by the mines management because it occupies less surface area but it is often vulnerable to failure, which leads to hamper the regular mine activity and production, loss of life, equipment and surrounding ecosystem. Failure of dump is also associated with environmental degradation like land, water, air and ecological changes[1, 29].Flatter dump requires more land which is also not an economical situation for the mine management. Land availability is limited and complicated to manage the dump in the demarcated land; the best solution is to optimize the slope for better dump material adjustment[30].

4. Problem to be investigated

I. What are the plant species growing on OB dumps in the Sukinda chromite region?

II. Is density of plants on OB dumps important?

III. Is vegetation reduces soil run off?

IV. Is there any impacts on soil physical –chemical parameters?

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V. Can plant root enhances slope stability of OB dumps?

5. Objective of the research:

1. To quantify the plant density and species number on OB dumps.
2. To explore erosion from OB dumps.
3. To determine the shear strength of the dump materials (with and without plant) in in-situ condition and laboratory.
4. Quantification of factor of safety of overburden dumps enhanced due to plants.
5. To put forth the OB dump management

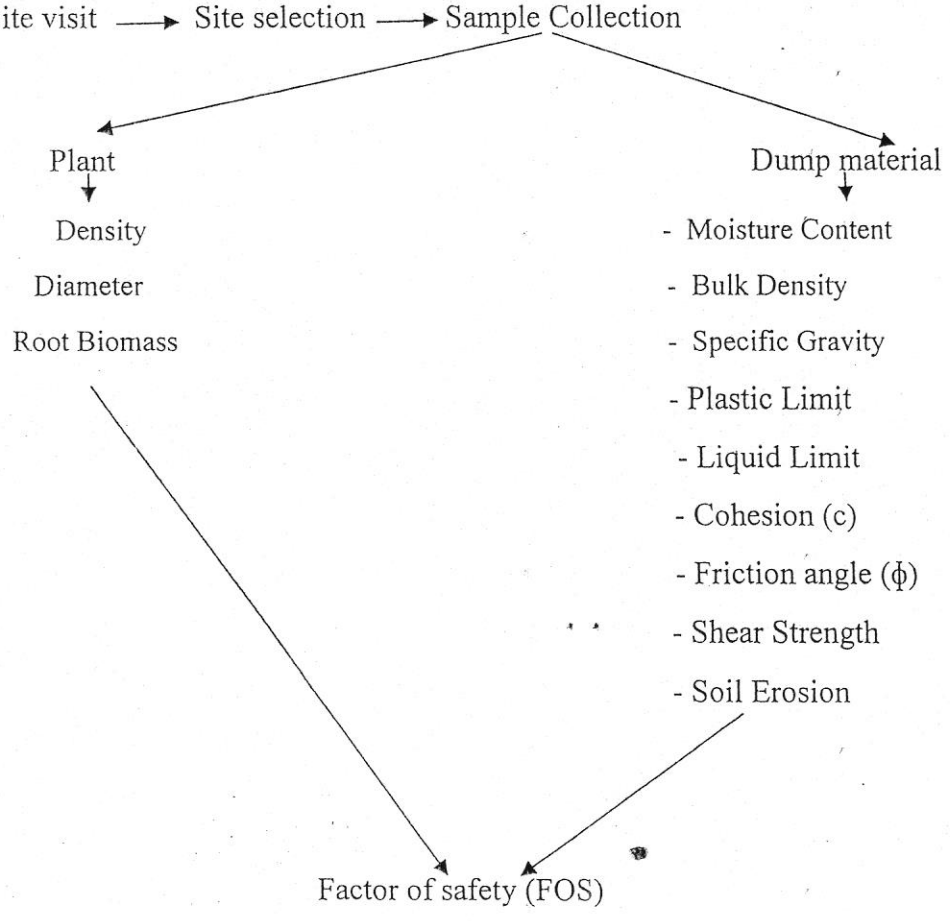
6. Hypothesis

We hypothesize that plants growing on dumps prevents soil erosion and enhances slope stability.

7. Research design and methodology:

RESEARCH DESIGN

i. Site visit → Site selection → Sample Collection



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STUDY AREA

The dumps of Indian Metal & Ferro Alloys Ltd (IMFA) and Odisha Mining Corporation (OMC) have been selected for the proposed study, These mines are situated in Orissa state and are about 55 km away from Jajpur Keonjhar railway station (on Howrah – Vishakhapatnam route) of East Coast railway. Location of site is given in Fig.1.

First Year Plan:

Extensive literature survey will be carried out in order to obtain information of open cast mines about recent activities in revegetation and slope stabilisation of overburden dump of open cast mines. Literatures help to understand and compare various recentadopted techniques and to finalize the most suitable methodology. This will help to design an appropriate revegetation plan toprevent slope failure and to enhance the overburden dump slope stability.

Second Year Plan

Analysis of sample for both physical and chemical properties of OB dumps, experimental tests will be done at CSIR –CIMFR, Dhanbad laboratory and at field. The tensile strength of root will be also determined. Determination of soil cohesion (c) and internal friction angle (ϕ) in lab as well as in- situ field condition. Slope stability analysis for factor of safety determination purpose will be performed. The data will be statistically analysed and interpreted to be incorporated in the thesis.

Third year Plan

The thesis will be prepared, printed and submitted in this year.

METHODOLOGY:

1. Plant density and root proliferation (root biomass) will be measured by different methods.
2. Physical parameters of soil will be measured by as per standard methods.
3. Chemical characteristic of soil will be done.
4. Factor of safety will be measured with the help of software (FLAC, GALENA).
5. On the basis of analysis of data dump management plan will be given.

8. Tools to be used in the collection of data and analysis:

I. Measuring tape

II. Quadrate

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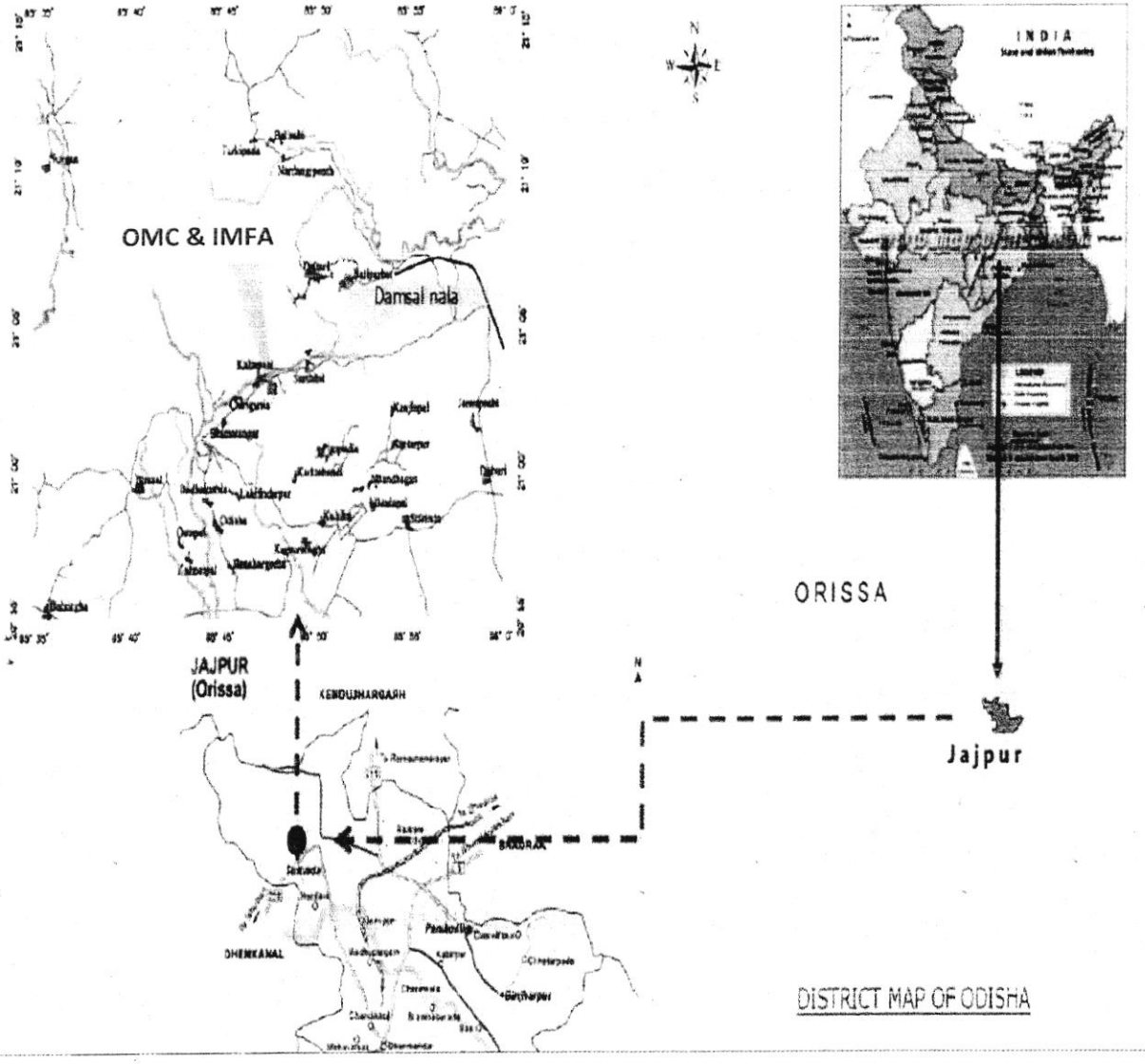

Figure 1: Location of OMC & IMFA dumps in Jajpur District of Odisha selected for the study

III. Soil sampler, Hammer

IV. Balance, Kings cup, Bulk density cylinder,oven, direct shear test machine

V. Total station

VI. Galena Software

VII. FLAC Software

9. Significance of proposed Work:

The study has great implications for social impact; it will save the infrastructure, land damage, vegetation improvement, and cleaner environment. Which ultimately save human life and wild life population. On this basis eco friendly mining can enhance the standard of the living of the people.

10. Contribution to the Existing Knowledge:

Several studies have been carried out in the coal mining areas. These studies are fragmentary. However there is lack of understanding and knowledge of the chromite mines located in Orissa. Present investigation can add the OB dump management to enhance the production of chromite from the mines and reduce the slope failure which is disastrous to human and animals.

11. Future Work:

Present findings will enhance the slope stability of chromite mines overburden dumps. The finding will create several investigations for future work in iron ore mine overburden dumps, diamond ore overburden dumps, zinc waste overburden dumps, phosphate waste overburden dumps and manganese overburden dumps.

References:

1. Singh RS, Ttipathi N,Chaulya SK. Ecological study of revegetated coal mine spoil of an Indian dry tropical ecosystem along an age gradient, Biodegradation, 2012, DOI 10.1007/s10532-012-9573-6.
2. Fisher RF. Amelioration of soils by trees. In Gessel SP, Lacte DS, Weetman GF, Powers RF (eds) Sustained productivity of forest soil. Proceeding of 7th North American forest soils conference, Vancouver, BC, PP 24-28 July.1988.University of British Columbia, and Faculty of For. Publ. Vancouver, BC, 1990, pp525.
3. Stoke A, Spanos I, Norris, JE, Cammeraat LH. ECO-and ground bio-engineering: The use of vegetation to improve slope stability. Developments in Plant and Soil Science, Dordrecht. The Netherlands, Springer, 2007, 103,438.
4. Ali F. Use of vegetation for slope protection: Root Mechanical Properties of some tropical plants. International Journal of Physical Science, 2010, 515,496-506.

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5. Tiwari RC, NP, Bhandary RY, Bhat DR. Evaluation of factor of safety for vegetated and barren soil slope with limit equilibrium computations, Geomechanicsand Geoengineering : An International Journal,2013, http://dx.doi.org/10.1080/17486025.2012.744101

6. Gray DH, Brenner RP. The hydrology and stability of cutover slope, Proc. Interdisciplinary Aspects of Watershed Management, ASCE, New York, 1970, 295-326.

7. Greenway DT. Vegetation and slope stability, in slope stability (eds.by M.G Anderson and K.S. Richards), John Wiley, New York, 1987, 187-230.

8. Filcheva E, Noustorova M, Kostadinova GSV, Haigh MJ Organic accumulation and microbial action in surface coal mine spoils, Pernik, Bulgaria. EcolEng, 2000, 15, 1-15.

9. Banov M, Hristov B, Filcheva E, Georgiev B. Humus accumulation and its quality composition and its Quality composition in reclaimed lands. In One hundred and years of the Bulgarian Academy of Science and 65 years of the Forestry Institute, Scientific papers from the jubilee symposium. Institutza Gorata, Bulgarska Acadamiiyana Naukite Sofia, 1995, pp 279-285.

10. Normaniza O, Barakbah SS. Parameters to predict slope stability – soil water and root profiles. EcolEng 2006, 28, 90-95.

11. Singh JS, Singh KP, Jha AK. An Integrated ecological study on revegetation of mine spoils. Final Technical Report submitted to the Ministry of Coal. Government of India. New Delhi 1996a.

12. Chaulya SK, Singh RS, Chakraborty MK, Tewary BK. Bioreclamation of coalmine overburden dumps in India. Land Contam Reclam, 2000, 8(3), 189-199.

13. Jorgensen SE. Model as Instruments for contribution of ecology theory and environmental practice. Ecol Model. 1994, 75/76, 5-20.

14. Cherubini C, Giasi C. The influence of vegetation on slope stability. In: Marinos PG, Koukis GC, Tsiambaos GC, Stournaras GC (eds) Proceeding of engineering geology and environmental, vol. I.A.A Balkema, Rotterdam, 1997, pp 67-71.

15. Hussain A. Fill compaction-erosion study in reclaimed areas. Indian Min Eng. 1995, J34, 19-21.

16. Hall BE, Giles EL, Rauch HP. Experiences with the use of trees in slope stabilization. In: Proceedings of XIII ICSMFE, New Delhi. 1994, pp 1231-1235.

17. Waldron LJ, Dakessian S. Shear resistance of root-permeated homogeneous and stratified soil. Soil Science Society of America Journal, 1977, 41, 843-849.

18. Gray DH. Role of woody vegetation in reinforcing soils and stabilising slops. Symposium of Soil Reinforcing and Stabilizing Techniques, Sydney, 1978, pp-253-306.

19. Bast A, Wilcke W, Graf F, Lüscher P, Gärtner H. The use of mycorrhiza for eco-engineering measures in steep alpine environments: effects on soil aggregate formation and fine-root development. Earth Surf. Processes Landforms, 2014, 39 (13),1753–1763.

20. Jastrow JD. Changes in soil aggregation associated with tall grass prairie restoration. Am. J. Bot. 1987, 74, 1656–1664.

21. Reubens B, Poesen J, Danjon F, Geudens G, Muys B. The role of fine and coarse roots in shallow slope stability and soil erosion control with a focus on root system architecture: a review. Trees, 2007, 21 (4), 385–402.

22. Vergani C, Graf F. Soil permeability, aggregate stability and root growth: a pot experiment from a soil bioengineering perspective. Ecohydrology, 2015, 9, 830–842.

23. Amezketa E. Soil aggregate stability: a review. J. Sustainable Agric. 1999, 14, 83–151.

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24. DASH AK. Analysis of accidents due to slope failure in Indian opencast coal mines, Current Science, 2019, 117(2), 304-308.

25. Roy SK., Singh JK. Scientific study to ascertain the causes and circumstances of strata failure on 23.07.2019 at Bharatpur OCP, Bharatpur Area, MCL, CSIR-CIMFR Project Report No.CNP/4949/2019-20, March 2020.

26. DGMS (Director General of Mine Safety) (Tech) (S&T) Circular No.02 dated 06.07.2010.

27. Steiakakis E, Kavouridis K, Monopolis D. Large scale failure of the external waste dump at the "South Field" lignite mine, Northern Greece. EngGeol, 2009 104, 269-279.

28. Poulsen B, Khanal M, Rao AM,Adhikay D. Mine overburden dump failure: A case study . Geotech Geol. Eng. 2014, 32, 297-309.

29. Singh TN,Barde KS, Purwar N, Gupta S,Sarkar K Effect of heightening on overburden spoil dump stability.MinEng J., 2007, 2, 16-23.

30. Vishal V, PradhanSP,Singh TN. Mine sustainable development vis-avis dump stability for a large open cast mine. In: Proceedings of international conference on the earth science and engineering, 2010, pp1-7.

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